

12 EUROPEAN PATENT APPLICATION

21 Application number: 84100403.9

51 Int. Cl.³: B 60 L 15/20
B 61 L 3/00

22 Date of filing: 16.01.84

30 Priority: 17.01.83 JP 5641/83
09.06.83 JP 103487/83

43 Date of publication of application:
01.08.84 Bulletin 84/31

84 Designated Contracting States:
DE FR GB

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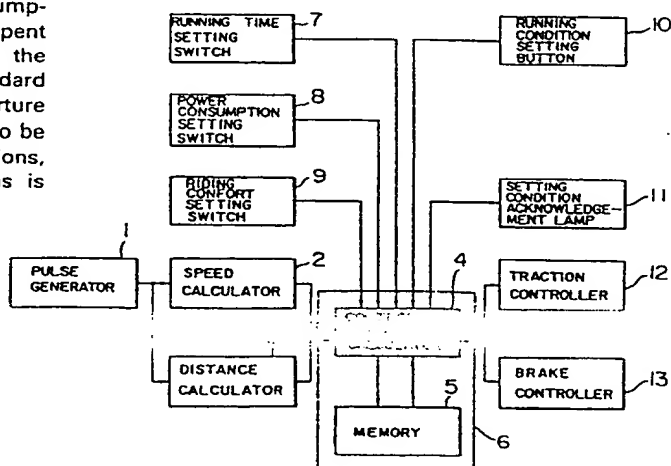
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54 Method for automatic operation of a vehicle.

57 This invention relates to a method of automatic vehicle operation which fulfills multi-dimensional performance indices by presetting the weight for power consumption, the weight for the riding comfort, and the like. The modifying running time relative to the standard running time to be spent between two stations, the allowable power consumption relative to the standard power consumption to be spent for the standard running between two stations, and the degree of improvement of riding comfort for the standard running between two stations are set prior to the departure from a station so as to determine control parameters to be used for divided regions of distance between two stations, and the speed of the vehicle between two stations is controlled using the selected control parameters.

FIG. 1



METHOD FOR AUTOMATIC OPERATION OF A VEHICLE

1 The present invention relates to a method for
automatic operation of a vehicle and, particularly, to a
method of automatic vehicle operation capable of fulfilling
the multi-dimensional performance indices by operating
5 a train or the like in accordance with predetermined
control parameters selectively.

 Recently, methods of automatic operation of a
train have been put into practice in various places in
the world. In these conventional methods, a target speed
10 pattern is generated, and control commands are issued to
the traction controller or brake controller so that the
actual train speed follows the target speed pattern (For
example, refer to Japanese Patent Laid-open No. 57-36505.)
For operating a train between two stations, according to
15 these methods, a number of running patterns are prepared in
advance and the train is operated by selecting and switch-
ing the running patterns depending on situations such as
a delay on the train diagram. These methods are solely
oriented to bring a train conformable to the diagram
20 through the selection of a running pattern based on the
running time. More recently, however, there arise demands
for lower power consumption and better riding comfort
in addition to the accurate operation on the train diagram.
Examples of new demands are 10% power reduction in the
25 summer season when the gross power consumption hits the peak

1 and better riding confort without vibration when passengers
are rare, and the operation based on such multi-dimen-
sional performance indices is not possible by the
conventional method for the automatic train operation.

5 It is an object of the present invention to
provide a method for automatic vehicle operation capable
of fulfilling the multi-dimensional performance indices
by setting weights for the power consumption, riding
confort, and so on. The invention resides in the method
10 for the automatic vehicle operation for controlling the
running of a vehicle between stations by use of the pre-
determined control parameters, wherein the distance between
two stations is divided into a number of regions, perform-
ance indices as a result of application of a set of
15 control parameters to each region are evaluated, and the
control parameter used in each region is determined by set-
ting the performance indices in advance. The performance
indices include the running time between two stations,
power consumption, and riding confort.

20 The present invention will be more apparent
from the following detailed description taken in conjunction
with the accompanying drawings, in which:

Fig. 1 is a block diagram of the automatic
train operation controller according to the first embodi-
25 ment of the present invention;

Fig. 2 is a chart showing an example of segmenta-
tion of the distance between two stations;

Fig. 3 is a table showing the values of

1 performance indices corresponding to the control parameters;

Fig. 4 is a layout diagram of the running
condition setup console of the first embodiment;

5 Fig. 5 is a flowchart showing the process of
selecting control parameters by the microcomputer system
embodying the present invention;

Fig. 6 is a flowchart showing the process of
train control by the microcomputer system embodying the
present invention;

10 Fig. 7 is a block diagram of the automatic train
operation controller according to the second embodiment
of the present invention;

Fig. 8 is a graph used to explain kinetic energy
possessed by a train running between two stations;

15 Fig. 9 is a graph used to explain the train
speed in the same operating condition as of Fig. 8;

Fig. 10 is a table showing the contents of the
condition table provided in correspondence to the ground
markers shown in Fig. 7;

20 Fig. 11 is a table showing the contents of the
alternative table shown in Fig. 7 for power-saving control;

Fig. 12 is a flowchart showing the process
carried out at train departure by the microcomputer
according to the second embodiment of the present invention;

25 Figs. 13A and 13B are flowcharts showing the
process of train control; and

Fig. 14 is a flowchart of the process of
selecting a column of alternative table for the power

1 saving control.

In Fig. 1 showing in block diagram the automatic train operation controller according to the first embodiment of the present invention, reference number 1 denotes a pulse generator which generates pulses in proportion to the running distance of the train, and 2 denotes a speed calculator which sums distance pulses produced by the pulse generator 1 to yield the train speed from the running distance of the past one second. Reference number 3 is a distance summation unit which sums distance pulses since the train has started from a station so as to yield the running distance L from the station. These devices 1, 2 and 3 are disclosed in the above-mentioned Japanese Patent Publication. Reference number 7 denotes a switch for setting the running time to be spent until the train will reach the next station, 8 denotes a switch for setting the power consumption, 9 denotes a switch for setting the riding comfort factor, 10 denotes a button for directing the setup of the running conditions, and 11 denotes a lamp which indicates in blue that there exists a combination of control parameters which suffices the setting condition, or indicates in red that such combination does not exist, thus prompting the reentry of the running condition. Reference number 4 is a unit which determines control parameters in accordance with the setup of running conditions on the switches 7, 8 and 9, and calculates control commands (powering and braking), and 5 denotes a unit for storing data of running time,

1 power consumption and riding confort for combinations
of control parameters obtained in advance by experiment or
simulation. Reference number 12 denotes a traction con-
troller which accelerates the train in response to the
5 traction control command, and 13 denotes a brake control-
ler which decerelates the train in response to the brake
control command. Among these devices the control command
calculator 4 and memory 5 are realized by use of a micro-
computer 6 in this embodiment. The traction controller 12
10 and brake controller 13 are the units disclosed in the
above-mentioned Japanese Patent Publication, and detailed
explanation thereof will be omitted.

Fig. 2 is a chart explaining by way of example
the segmentation of the distance between two stations, and
15 Fig. 3 is a table of performance indices for the control
parameters.

As shown in Fig. 2, the distance from the depart-
ing station to the arriving station is divided into three
regions, i.e., regions 1, 2 and 3, and a control parameters
20 is determined for each region by making reference to the
performance index table. The curve V in Fig. 2 represents
the train speed as a result of train operation using the
control parameters, and the straight lines at the top of
the figure represent two limited speeds. The memory 5
25 stores a performance index table as shown in Fig. 3.

According to the present invention, a plurality
of control parameters responsive to the requirements of
running time reduction, power consumption cut, and

1 improvement of riding confort are prepared, the values
of performance indices of the running time, power consumption and riding confort as a result of running using any
one of the control parameters in one region between
5 two stations are obtained experimentally or computer
simulation, and a table of performance indices for one set
of combination is prepared in advance. Then, conversely,
when performance indices are specified, a control parameter
for each region is determined.

10 As shown in Fig. 3, the performance index table
contains the control parameter table number (1, 2, or 3),
evaluation of riding confort (good or bad), and running time
(time reduction or delay in seconds) for each region.

Fig. 4 shows an example of the running condition
15 setup console. The console is provided thereon with running
time setting switches (-10, -5, 0, +5, and +10 sec)
7, power consumption setting switches (80, 90, 100, 110,
and 120%) 8, riding confort setting switches (BAD, USUAL
and GOOD) 9, a running condition setting button 10, and
20 a setup acknowledgement lamp 11.

Fig. 5 is a flowchart showing the control
parameter selection process using a microcomputer according
to the first embodiment, and Fig. 6 is a flowchart of
processing for operating the train using the selected
25 control parameter. Fig. 5 shows the process of selecting
a combination of control parameters used for the running
between two stations A and B, or the setup console 11.
This program is initiated when the running condition

1 setting button 10 is pressed. The program reads the
running time setting switches 7 (step 501), the power
consumption setting switches 8 (step 502), and the riding
confort setting switches 9 (step 503) sequentially, and
5 then searches the tables of n in number (Fig. 3) in the
memory 5 for a combination of control parameters which
meet the values of performance indices which have been read
(step 504). If no satisfactory control parameter is found,
the program lights the setup acknowledge lamp 11 in red
0 (steps 505 and 506), or when satisfactory control param-
eters are found, the program lights the setup acknowledge
lamp 11 in blue and sets the combination number i of the
control parameters in the memory 5 (steps 505 and 507).

Fig. 6 shows the process of operating the train
5 in accordance with the combination of control parameters
obtained in the process of Fig. 5. This program is initiated
in response to the departure command. The program
first calculates the distance L of the immediate position
from the departing station by the distance summation
10 unit 3 (step 601). Then, the program determines the
region number j (e.g., 1, 2 or 3 in Fig. 2) from the
distance L (step 602) and determines a control parameter
to be selected in the table of Fig. 3 for the current
region from the control parameter combination number i and
15 the region number j (step 603). Next, the program issues
a control command to the traction controller 12 or brake
controller 13 basing on the selected control parameter
(step 604). When the train reaches the arriving station,

1 the process is terminated, or otherwise, the program is
restarted from the beginning (step 605).

Accordingly, the present invention uses the
conventional hardware equipment except for the additional
5 button, switches and lamp (7-11) shown in Fig. 4 for set-
ting the running condition, and implements the new function
using the program stored in the microcomputer 6 and the
performance index table stored in the memory 5. Namely,
when power saving is requested in summer due to a high
10 demand of power, the running condition can be set with the
weight being placed at power reduction, or when the better
riding confort is requested, the weight can be placed for
it, and thus the running condition which meets each purpose
can be achieved. In addition, the running time can be
15 modified under the restriction of other performance
indices.

The performance tables shown in Fig. 3 are the
lists of performance indices as a result of running when
each control parameter is used for each region, and the
20 control parameter tables Nos. 1, 2 and 3 are the lists
of control commands to be issued to the traction controller
12 and brake controller 13.

Although in the foregoing embodiment the distance
between two stations is divided by measuring the distance,
25 the invention is not limited to this, but for example
a control parameter may be selected by detection of signals
located at positions between two stations. Although in the
foregoing embodiment reference values of performance

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1 indices are given through the switches, they may be
given from the computer of the central operation office
through the communication line in advance of departure.
It is also possible to execute the process shown in Fig. 5.
5 by the computer in the central office and transmit only
the result to the train.

According to the first embodiment of the invention,
as described above, a plurality of sets of control
parameters are prepared, the distance between two stations
10 is divided into a plurality of regions, performance
indices as a result of running when each control parameter
is used for each region are prepared as tables, and control
parameters to be selected in regions are determined on the
basis of the requested performance indices in advance of
15 the departure of the train, whereby the train can be
operated automatically with satisfactory multi-dimensional
performance indices such as power saving and better riding
comfort.

Next, the second embodiment of the invention will
20 be described. This is a method of automatic train operation
control between two stations using predetermined
control parameters, wherein one or more ground markers
are placed between two stations, and there are provided
a table containing the train speed, residual running time
25 and scheduled power consumption (per unit weight) estimated
when the train has passed each ground marker in a minimum
possible time and further a table containing the increased
running time and decreased power consumption in case

1 the lower target speed is lowered for a certain distance
after the train has passed each ground marker, so that
the lower target speed which meets the target running
time to the next station, that has been set before
5 departure, at the least power consumption is determined
when the train passes each ground marker.

The embodiment will now be described in detail.
Fig. 7 is a block diagram showing the second embodiment of
the automatic train operation controller. In the figure,
10 reference number 101 denotes a device for receiving the
limit speed signal at the current position of the train,
102 is a register for holding the limit speed signal, and
103 is a speed sensing generator. Reference number 104
is a speed calculator which counts distance pulses produced
15 by the speed sensing generator 103 to calculate the train
speed v from the running distance in a past second. Refer-
ence number 105 is a running distance calculator which
counts distance pulses since the train has departed so as
to evaluate the running distance l from the departing
20 station. Reference number 106 is a ground marker placed
at a certain position between two stations, and a signal
is generated in a ground marker detector 107 when the
train passes the marker. The running distance measured
at the detection of the ground marker 106 may be used to
25 correct the error of the speed sensing generator.

Reference number 108 is a device for setting the
target running time spent until the train will stop at
the arriving station, and the device is set when the train

1 starts from the departing station.

The target running time and target power consumption are set either through the switches equipped on the train or from the computer in the central operation command office through the communication line. The scheduled arriving time and power consumption are displayed in the train.

Reference number 1018 denotes a microcomputer which realizes the control functions by executing the stored programs as will be described shortly. In Fig. 7, the program is divided into functional blocks. The microcomputer 1018 has a program 109 for calculating the upper target speed v_{TV} to be followed by the train based on the contents of the limit speed signal register 102 and a program 1010 which calculates the brake command based on the upper target speed v_{TV} and train speed v . Reference number 1011 is a table containing the values of potential energy possessed by the train located at positions at altitudes corresponding to the distance l from the departing station, and 1012 is a program for calculating the current potential energy (altitude) of the train from the distance l . Reference number 1013 is a condition table corresponding to the ground markers placed between two stations, 1014 is an alternative table for power-saving control containing the values of increased running time and saved power consumption achieved when the target power consumption is varied at each ground marker for a certain distance, 1015 is a program for calculating

1 the target value of energy possessed by the train, 1016
is a program for calculating the lower target speed v_{TL}
by subtracting the current potential energy from the
target energy, and 1017 is a program for calculating the
5 traction command from the lower target speed v_{TL} and train
speed v .

The automatic train operation controller of
Fig. 7 controls the train speed using the target arrival
time and power consumption calculated when the train has
10 passed a certain position, based on the rule that the
train is operated always in the same running pattern by
the automatic operation for the maximum running perform-
ance thereby to achieve the minimal running time and
power consumption, and in the case of alteration of control
15 at a certain position between two stations, the original
minimal running pattern can be restored with a certain
increase in running time and decrease in power consump-
tion.

Fig. 8 is a graph used to explain energy possess-
20 ed by the train running between two stations, plotting
the sum of potential and kinetic energies of the train
on the ordinate against the distance from the departing
station on the abscissa. On the graph, curve 1022 shows
the kinetic energy at the limit speed, curve 1022 shows
25 the kinetic energy at the upper target speed, curve 1023
shows the standard running energy pattern, curve 1024
shows the power-saving running energy pattern, and curve
1025 shows the potential energy of the train.

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When the train is operated to run in a minimal time by simply following the upper target speed v_{TV} , the standard running energy pattern 1023 shown in Fig. 8 will be followed. Here, the power-saving running energy pattern 1024 is shown, in which ground markers are placed at three positions l_{C1} , l_{C2} and l_{C3} , and the train is operated to run following the lower target energy setup distance and its energy value at each position, (l_{E1}, E_{P1}) , (l_{E2}, E_{P2}) and (l_{E3}, E_{P3}) . This pattern is achieved by coasting. Declination of the curve is caused by the energy loss due to the running resistance such as the air resistance of the train.

Fig. 9 is a graph showing the train speed on the ordinate plotted against the distance on the abscissa in the same operation as of Fig. 8. On the graph, 1031 indicates the limit speed, 1032 indicates the upper target speed, 1033 indicates the standard running speed pattern, and 1034 indicates the power-saving running pattern. The train speeds at ground marker positions l_{C1} , l_{C2} and l_{C3} are v_{C1} , v_{C2} and v_{C3} , respectively. These values of speed in Fig. 9 are proportional to values of energy shown in Fig. 8 subtracted by the potential energy at the respective positions.

Fig. 10 shows the contents of the table 1013 provided in correspondence to the ground markers shown in Fig. 7. The column for ground marker 0 contains the initial value of standard residual running time T_{CO} which is the minimum running time required at starting.

1 and the initial value of standard power consumption E_{co}
which is the power consumption per unit weight at starting.
Other column for ground marker i ($i \leq 3$) contains the
distance l_{ci} from the departing station, the threshold
5 speed v_{ci} for the standard run, the standard (minimum)
running time T_{ci} for the remaining distance, and energy E_{ci}
used for the remaining distance.

Fig. 11 shows the contents of the alternative
table 1014 for power-saving control shown in Fig. 7, and
10 the table contains only the power-saving control factor
 J ($J = 3$). This table indicates that the running time
will increase by ΔT_j and power will be saved by the amount
of ΔE_j if the train runs following the lower target
power consumption E_{pj} for a distance of l_{Ej} after the
15 train has passed the ground marker N_{Ej} , and also indicates
that if this control is carried out, the control table
of N_{Tj} is included in the control and cannot be used.
These values can be obtained by way of simulation or
through the experiment using the actual train.

20 Figs. 12, 13 and 14 are flowcharts of the
microcomputer embodying the present invention. The flow-
chart of Fig. 12 represents the operation of the proces-
sing program which is executed when the train starts.
The program, initiated in response to the start command
25 to the train, reads the running time between stations
set on the target running time setting device 81 so as
to set up the target running time (step 601), sets the
scheduled running time to the field of initial standard

1 running time (T_{co}) in the condition table 1013 (step 602),
sets the power consumption to the field of initial
standard power consumption (E_{co}) (step 603), and set the
power-saving control flag to "0" (step 604).

5 The flowchart of Figs. 13A and 13B shows the
processing of the train control program which is executed
at a sampling interval of Δt (e.g., 100 ms). The program,
when initiated, first subtract the sampling time Δt from
the target running time and scheduled running time (step
10 701). Subsequently, the program checks whether the power-
saving control flag indicating the selection of the
alternative table 1014 has a value j other than "0" (step
702), and reset the control flag (step 704) if the running
distance l is larger than the control completion distance
15 l_{Ej} (step 703). If the power-saving control flag is
"0" (step 705) or the running distance l is in the vicinity
of control completion distance l_{Ej} of column j of power-
saving control table under control e.g., 5 m to the end,
(step 706), the program selects the power-saving control
20 table (step 707). At this time, if the power-saving con-
trol flag is "0" (step 708), the lower target speed v_{TL}
is set larger (e.g., 200 km/h) (step 709), or if the
control flag has a value j (step 708), the lower target
speed v_{TL} is obtained from the lower target power consump-
25 tion E_{pj} per unit weight (having the unit of m^2/s^2) and
the potential energy E_h at the current position l obtained
from the running distance l with reference to the distance
vs. potential energy table 1011 (step 710).

1 The potential energy E_h and lower target speed v_{TL} are calculated from the following equations.

$$E_h = G \cdot h \quad (1)$$

$$v_{TL} = 3.6 \cdot \sqrt{E_{pj} - E_h} \quad (2)$$

where G is the gravitational acceleration (9.81 m/s^2), h is the altitude (m) of the current position l , and
5 constant 3.6 is a factor for converting the unit from m/s to km/h.

Subsequently, in Fig. 13B, the program calculates the upper target speed v_{TV} from a speed corresponding to the contents of the limit speed signal register 2 (step
10 711). Next, the lower target speed v_{TL} obtained previously is made lower than the upper target speed v_{TV} (step 712). Then, the program calculates the brake command BN from the upper target speed v_{TV} and the train speed v provided by the speed calculator 4, using, for example, the fol-
15 lowing equation (step 713).

$$BN = (v - v_{TV}) \cdot B_g \quad (3)$$

where B_g is the gain of the brake command applied to the deviation of speed.

Subsequently, if the brake command BN is produced (step 714); the traction command PN is made "0"
20 (step 715), or if the former is absent, the traction command is calculated using, for example, the following

1 equation (step 716).

$$PN = (v_{TL} - v) \cdot P_g \quad (4)$$

where P_g is the gain of traction command applied to the deviation of speed. The calculated brake command BN or traction command PN is fed to the drive/brake unit (step 5 717), and one cycle of processing is completed.

Fig. 14 shows the flowchart of the process for selecting the alternative table of power-saving control, and this is an expansion of the step 707 shown in Fig. 13A.

When the program enters this routine, it first
0 checks the ground marker detector 107 to see whether the train has passed a ground marker during a period between the previous and present execution of the routine. If it is found that the train has passed a ground marker i, the program checks whether or not the train speed v is
3 faster than the threshold speed v_{ci} which is the speed to achieve the minimum running time plus a marginal speed (e.g., 2 km/h) (step 801), and if this is true, the program proceeds to step 802. In case the train has passed the ground marker i at a speed faster than the
6 threshold speed v_{ci} , the standard residual running time T_{ci} and standard power consumption E_{ci} are set to the scheduled running time and power consumption (step 802).

Next, the whole alternative table for power-saving control 1014 is made effective (step 803). Subsequently, steps 805, 810 and 811 are carried out by incrementing the value of \bar{j} by the amount of power-

1 saving control factor J. Namely, checking is made
first whether the ground marker N_{Ej} for the beginning
of control in the jth column of table is equal to or
larger than the current ground marker i, and also whether
5 it is invalidated by the selection of other control
column (step 805). If the jth column can be selected,
the target running time is compared with the scheduled
running time added by the increased running time ΔT_j , and
if the train can run in time longer than the target running
10 time even under this control (step 806), this column j
control table is selected and the scheduled running time
is increased by the increased running time ΔT_j and schedul-
ed power consumption is decreased by ΔE_j (step 807). Next,
the control table N_{Tj} which has no effect during this
15 control is invalidated (step 808). If the ground marker
number for the beginning of control in the table is
equal to the ground marker number i which is currently
passed by the train, the power-saving control flag is
made to have value j (step 809). If the power-saving
20 control factor J is smaller than j, the program returns
to step 805, while incrementing j by one, and checks
whether the table can be selected (steps 810 and 811).

According to the present invention, the train
is operated while calculating the presumed arrival time
25 at the next station and power consumption time to time,
allowing the marginal time to be used for the power-saving
operation, and moreover, the train operation under the
specified power consumption is also made possible.

1 Although in the foregoing embodiment, the lower
target power consumption E_{pj} is set each position of
ground marker, the calculation related to potential
energy may be omitted if the railroad has small variation
5 of slope.

 The alternative table for power-saving 1014 of J
in number has the priority in the ascending order of
the number, allowing the marginal time to be spent later
and the like. The control table may be selected not only
10 based on the running time, but on the target power consump-
tion, or alternatively, it may be selected solely based
on the target power consumption.

 Although in the foregoing embodiment, the loca-
tion of the train is determined using ground markers,
15 it may be determined solely based on the running distance l
from the departing station. The output of the distance
calculator may be corrected using the running distance l
obtained from the count at the detection of the ground
marker and the actual distance l_{ci} in the table.

20 As described above, this embodiment has the
information table on the increased running time and saved
power consumption when train is operated to follow the
lower target speed or lower target power consumption after
the train has passed one or more positions between two
25 stations, allowing the selection of optimal control at
each position based on the target running time, target
power consumption, and the like, whereby the train can be
operated to meet conditions of arrival time at the next
station and power consumption.

CLAIMS:

1. A method for automatic operation of a vehicle in which predetermined control parameters are used to control the operation of a vehicle between two stations, wherein a plurality of sets of control parameters are prepared, performance indices reflecting the result of running of said vehicle when each of said control parameters is used for divided regions of distance between two stations are obtained, and a control parameter used in each region is determined by setting said performance indices in advance.
2. A method of automatic vehicle operation according to claim 1, wherein said performance indices include running conditions such as running time between two stations, power consumption, and riding confort.
3. A method of automatic vehicle operation according to claim 1, wherein said performance indices are set by operating switches (7, 8 and 9) provided on said vehicle or transmitted from a computer (6) in a central operation command office through a communication line.
4. A method of automatic vehicle operation according to claim 2, wherein said performance indices are set by operating switches (7, 8 and 9) provided on said vehicle or transmitted from a computer (6) in a central operation command office through a communication line.
5. A method of automatic train operation of a train between stations using predetermined control parameters with one or more given parameters set between stations,

comprising a first step of recording the train speed, residual running time and scheduled power consumption after the train has passed each of said ground markers on a schedule of minimum running time; a second step of recording the increased value of running time and decreased value of power consumption in case the lower target train speed is lowered when the train passes each of said ground markers; and a step of determining, when the train passes each of said ground markers, a lower target train speed which demands the least power consumption and satisfies a target running time to be spent until the train reaches an arriving station, said target running time being preset before the train has started from a departing station.

6. A method of automatic train operation according to claim 5, wherein said lower target train speed is determined by first setting a lower target power consumption with reference to a table of potential energy possessed by the train in correspondence to a running distance from the departing station, and next by subtracting a current potential energy of the train from said lower target power consumption.

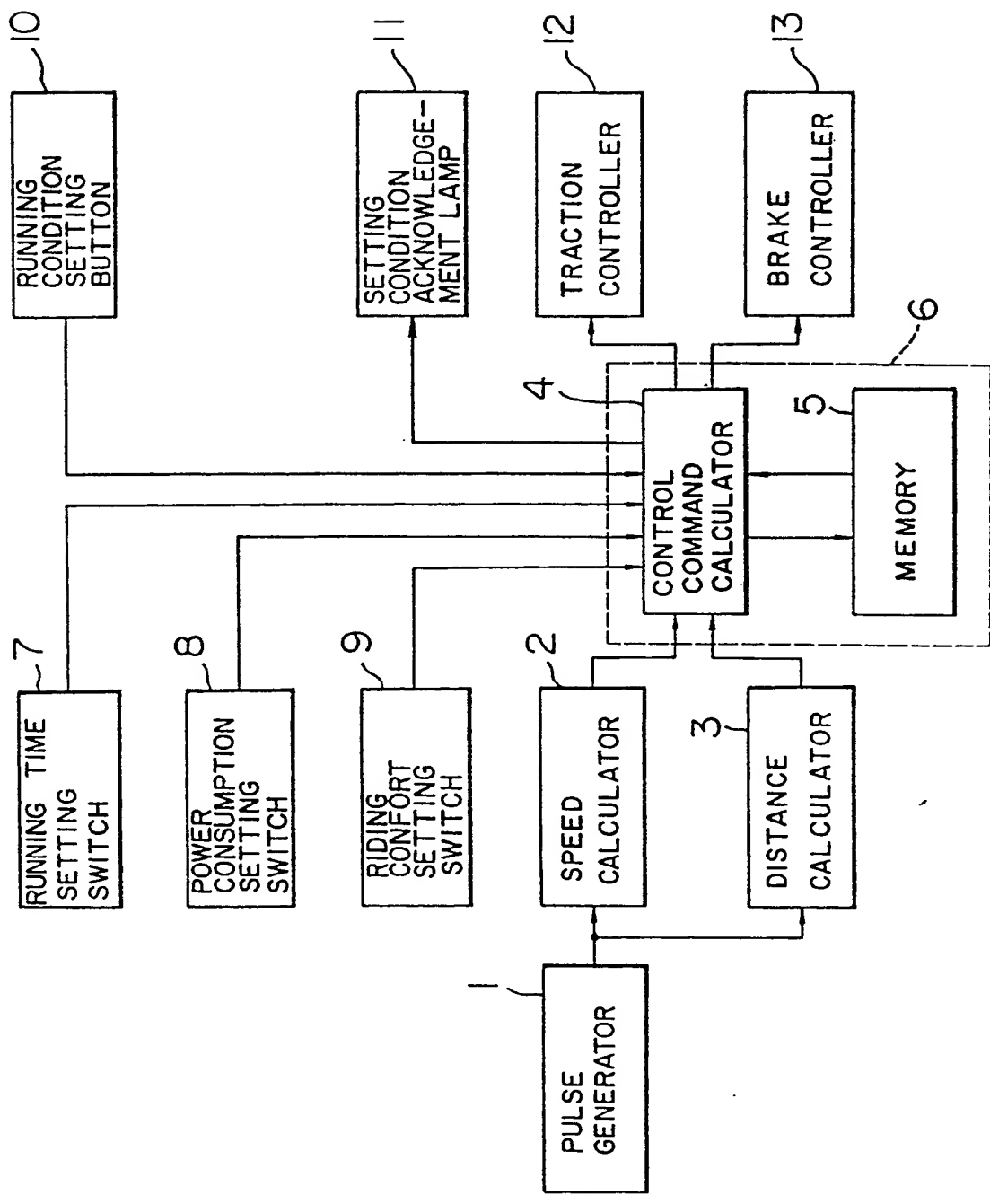
7. A method of automatic train operation according to claim 5 or 6, wherein said increased running time and decreased power consumption are recorded in a plurality of columns of table with priority levels appended thereto, so that a column of table is selected on a priority basis.

8. A method of automatic train operation according

to claim 5, 6 or 7, wherein said ground markers placed between stations is substituted by positional information which is derived from a running distance measured since the train has started from the departing station.

9. A method of automatic train operation according to claim 5, 6, 7 or 8, wherein said lower target speed or lower target power consumption is determined based on a target power consumption or the combination of a target power consumption and target running time instead of being determined solely from the target running time.

FIG. 1



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FIG. 2

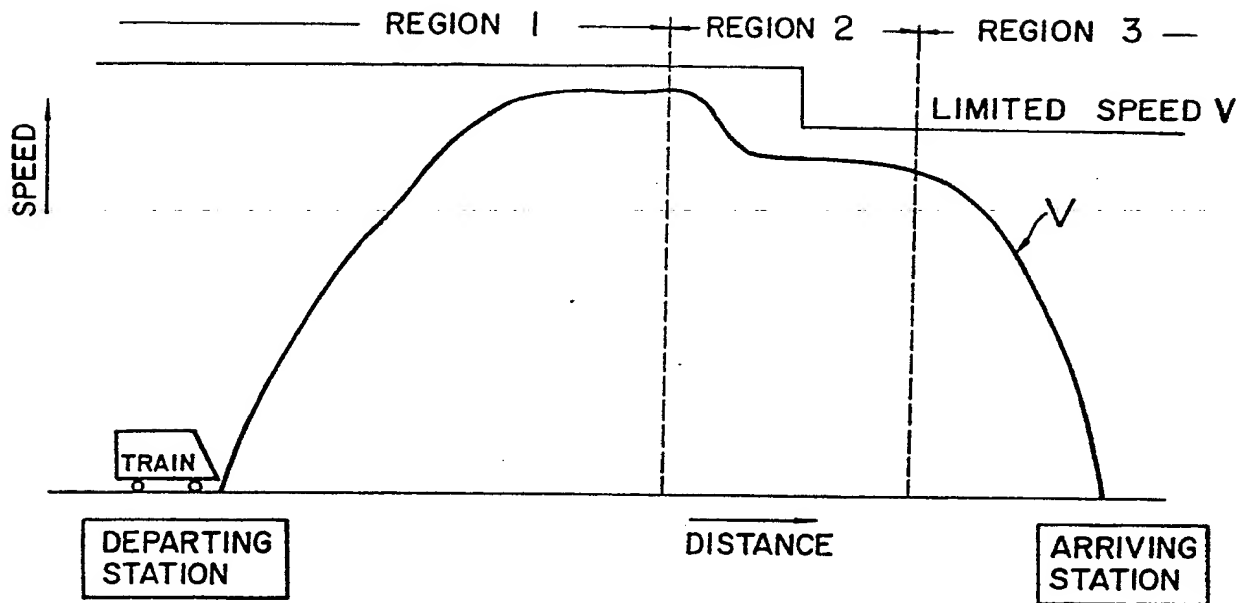


FIG. 3

No.	RUNNING TIME	POWER CON-SUMPTION	RIDING CONFORT	CONTROL PARAMETER TABLE NUMBER		
				REGION 1	REGION 2	REGION 3
1	± 0	100 ^(%)	USUAL	1	1	1
2	-5	90	USUAL	2	2	1
3	+5	110	GOOD	3	2	2
n	+10	80	USUAL	3	3	3

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FIG. 4

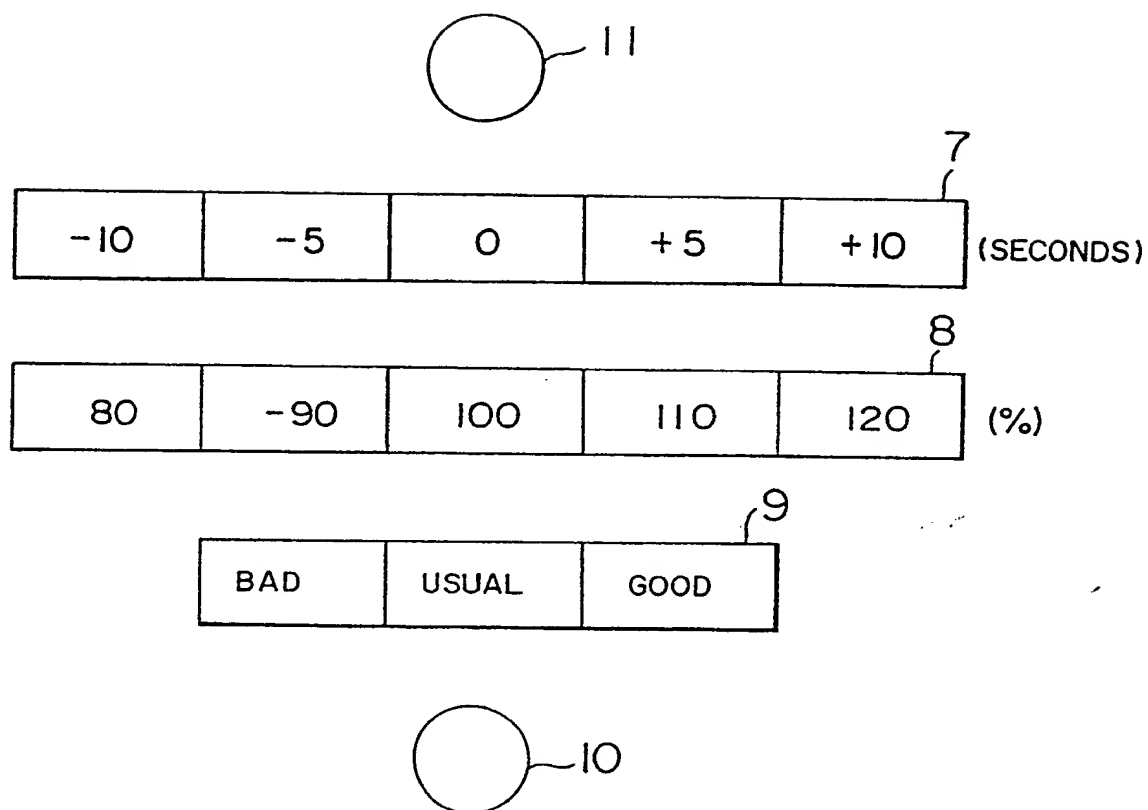
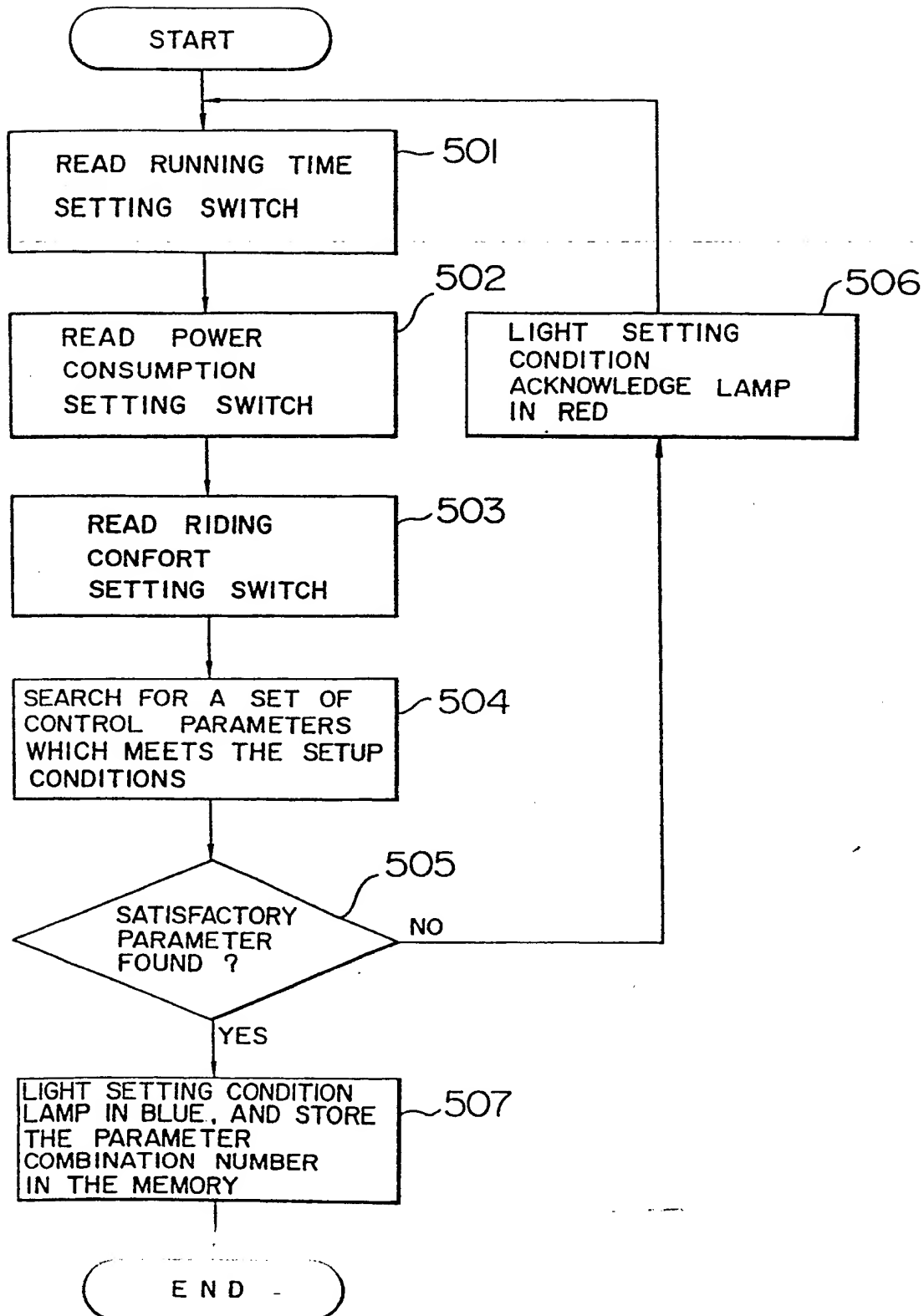


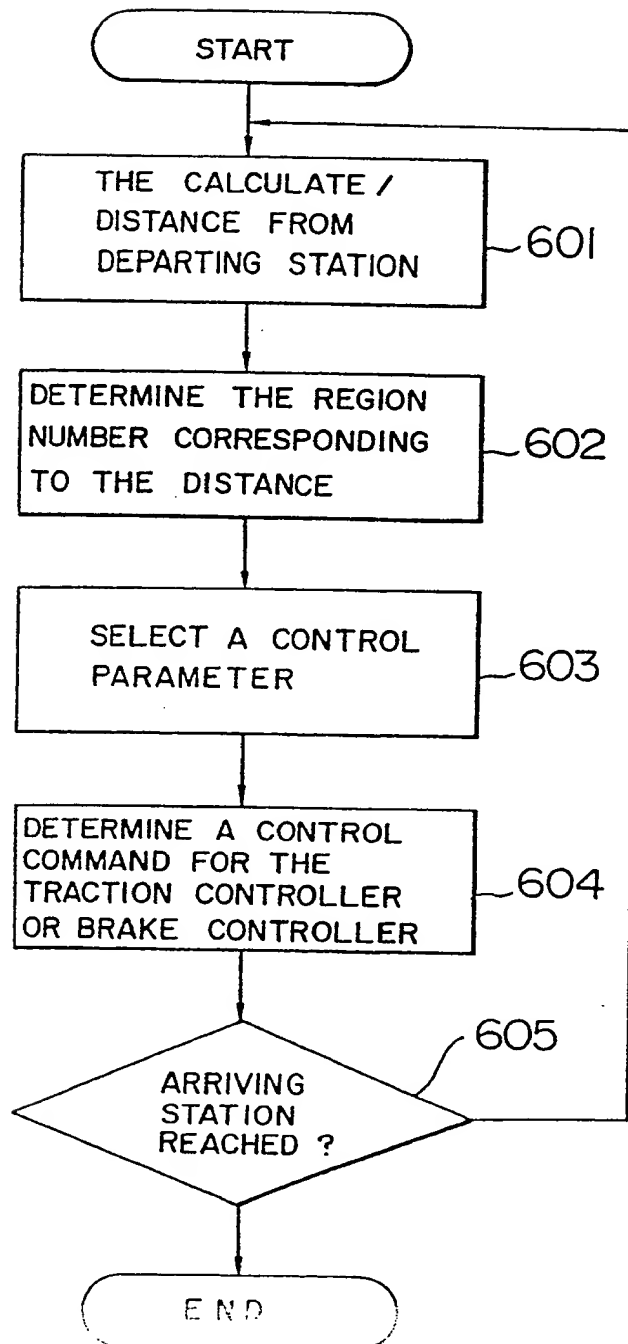
FIG. 5



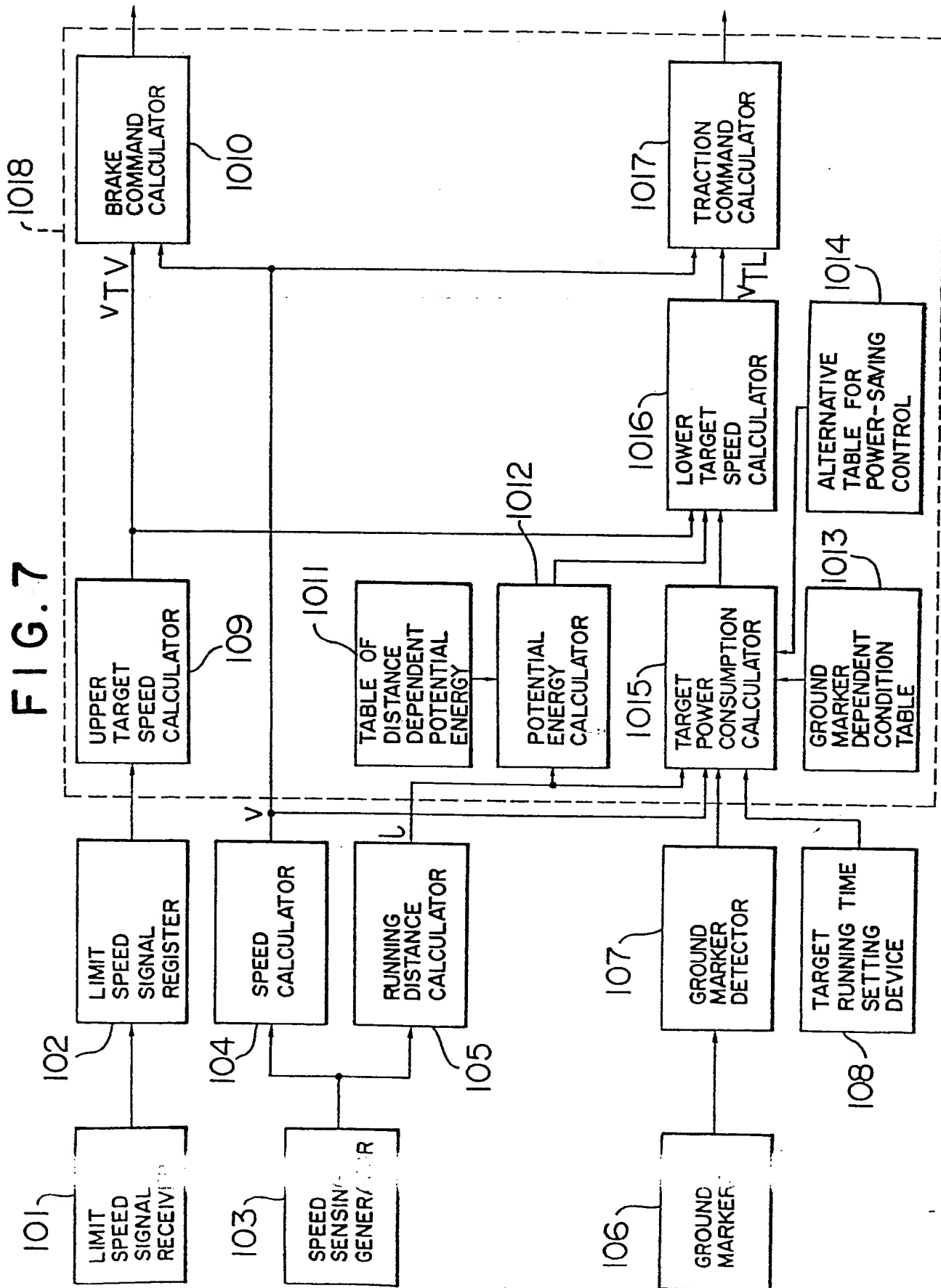
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FIG. 6



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FIG. 8

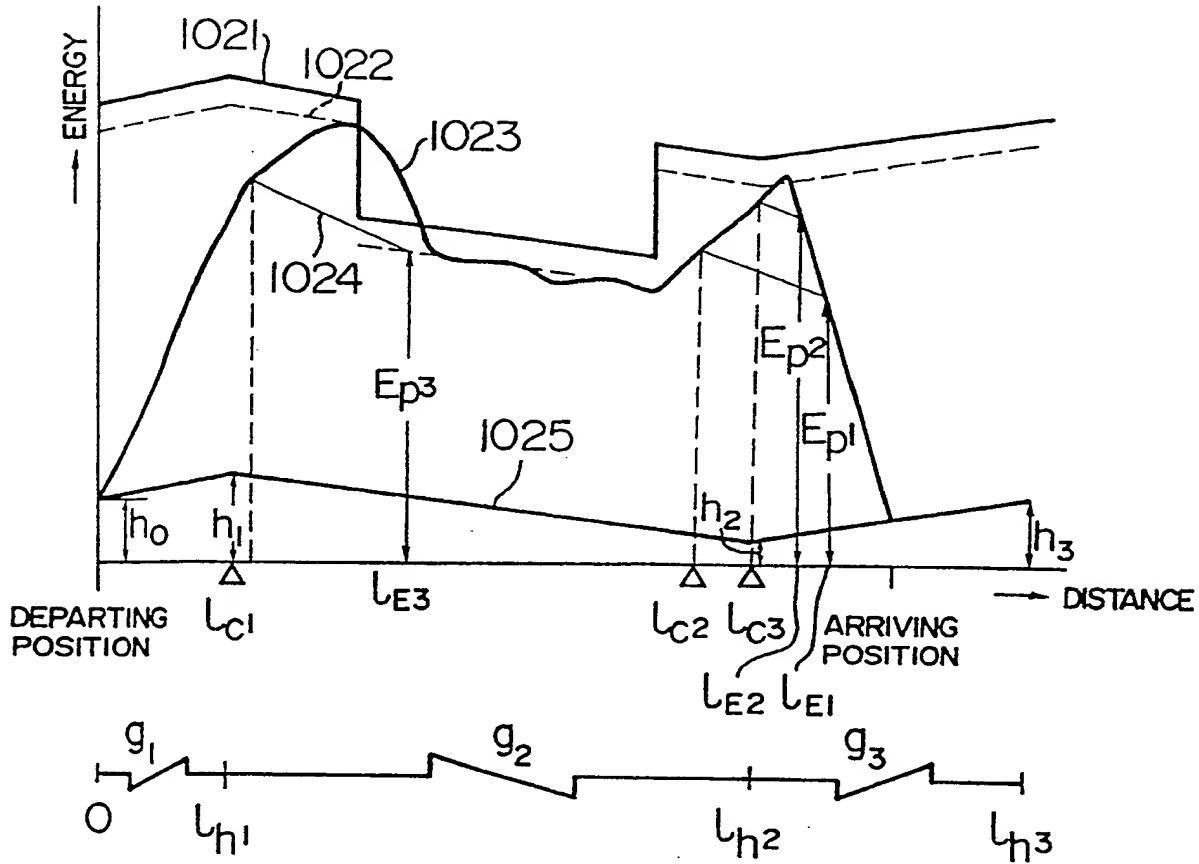


FIG. 9

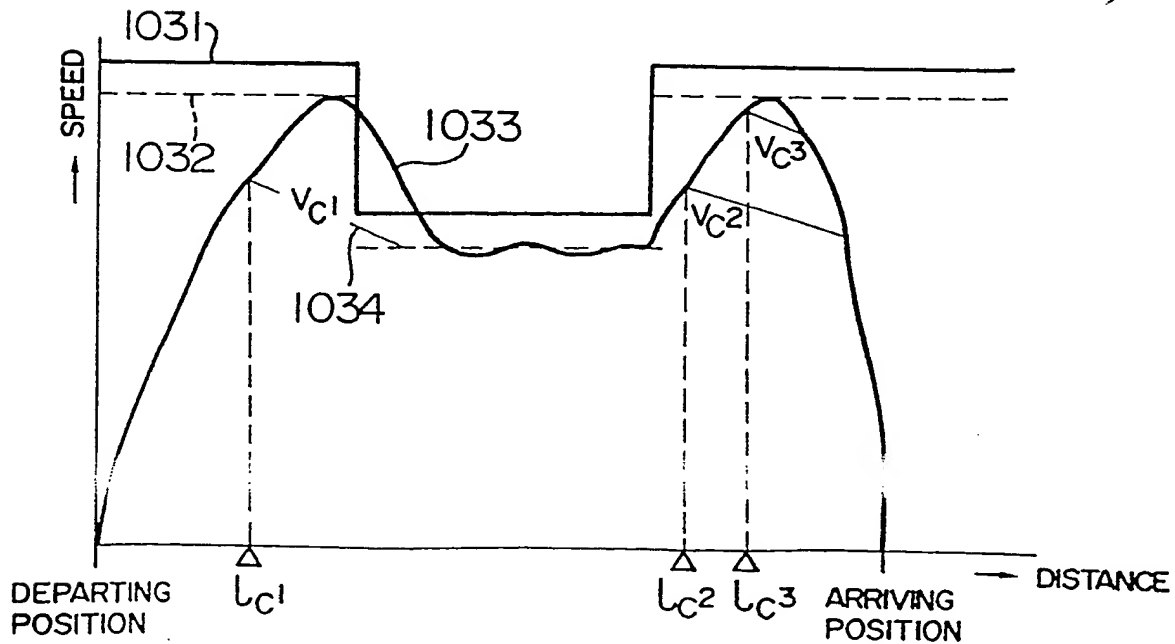


FIG. 10

GROUND MARKER NUMBER	GROUND MARKER POSITION	THRESHOLD SPEED	RESIDUAL RUNNING TIME STANDARD	STANDARD POWER CONSUMPTION
0	0	0	T_{C0}	E_{C0}
1	l_{C1}	v_{C1}	T_{C1}	E_{C1}
2	l_{C2}	v_{C2}	T_{C2}	E_{C2}
3	l_{C3}	v_{C3}	T_{C3}	E_{C3}

FIG. 11

POWER- SAVING CONTROL NUMBER	INCREASED RUNNING TIME	GROUND MARKER NUMBER	LOWER TARGET POWER CONSUMPTION	COMPLETE DISTANCE	SAVED POWER CONSUMPTION	TABLE NUMBER
1	T_1	$\Delta N_{E1} (= 2)$	E_{p1}	l_{E1}	ΔE_1	$N_{T1} (= 2)$
2	T_2	$\Delta N_{E2} (= 3)$	E_{p2}	l_{E2}	ΔE_2	$N_{T2} (= 0)$
3	T_3	$\Delta N_{E3} (= 1)$	E_{p3}	l_{E3}	ΔE_3	$N_{T3} (= 0)$

POWER- SAVING CONTROL FACTOR
$J (= 3)$

FIG. 12

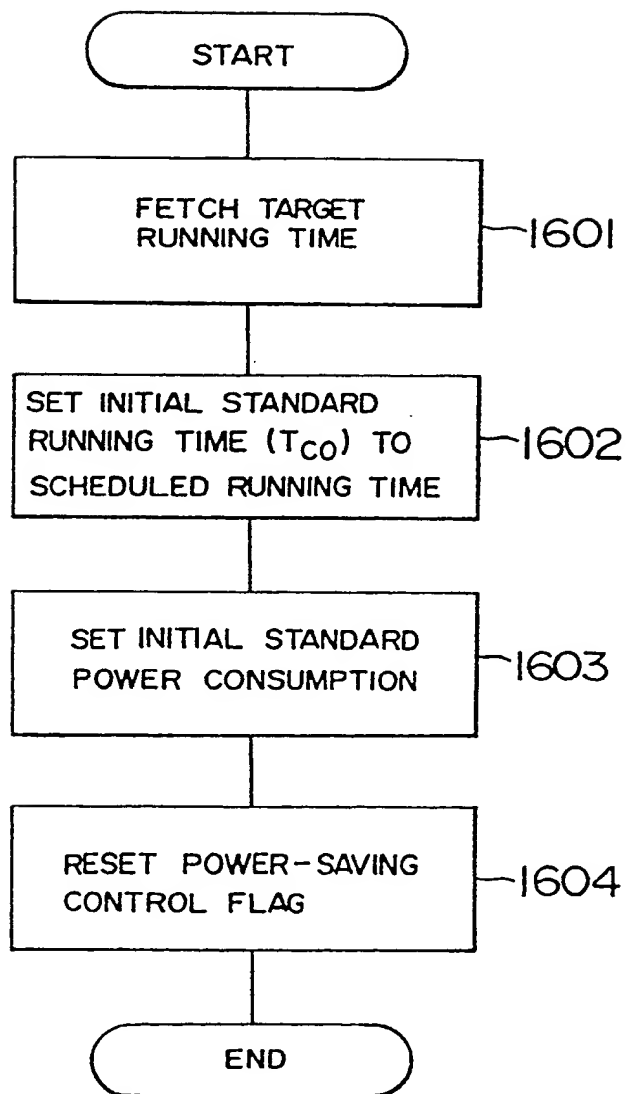


FIG. 13A

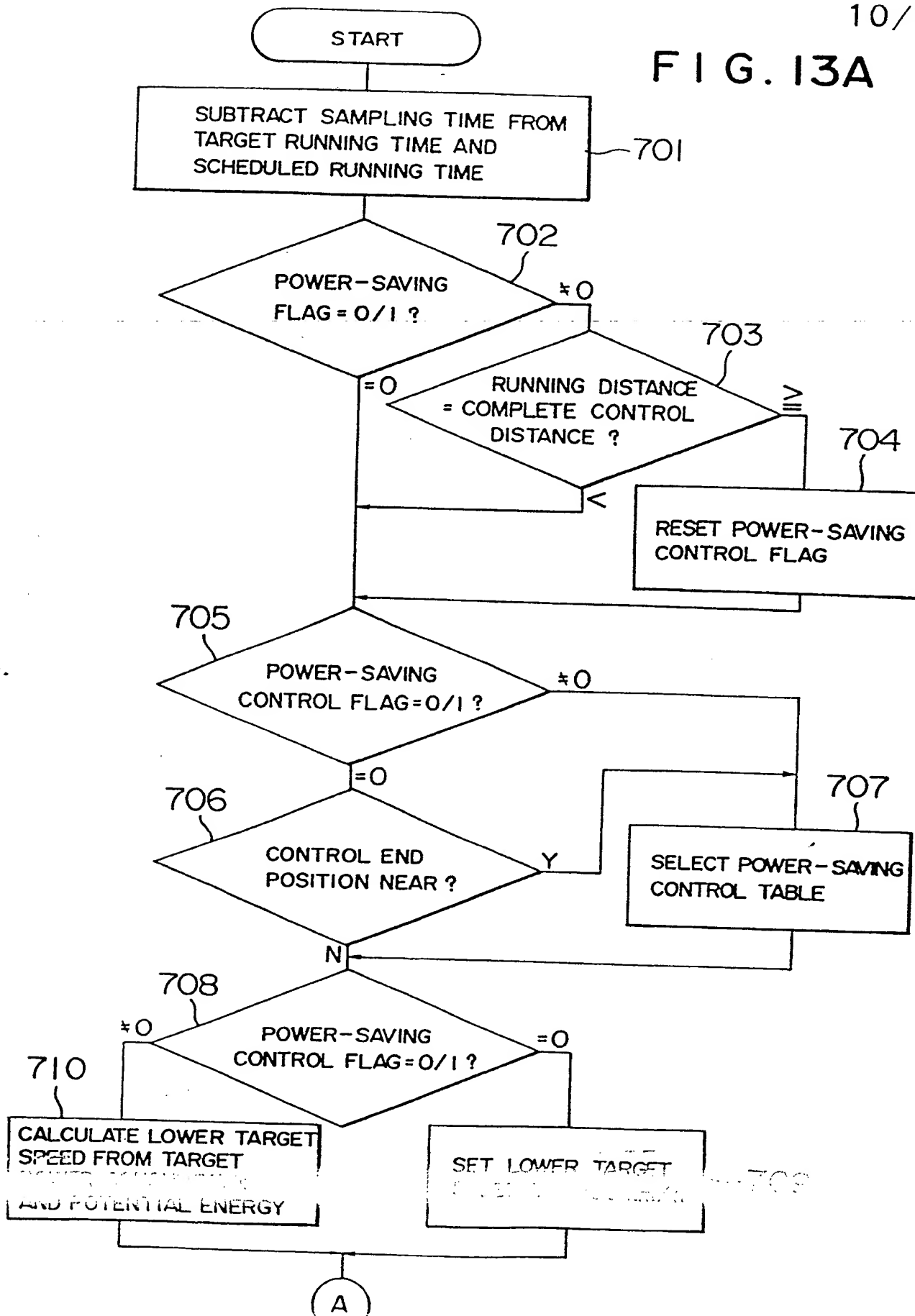


FIG. 13B

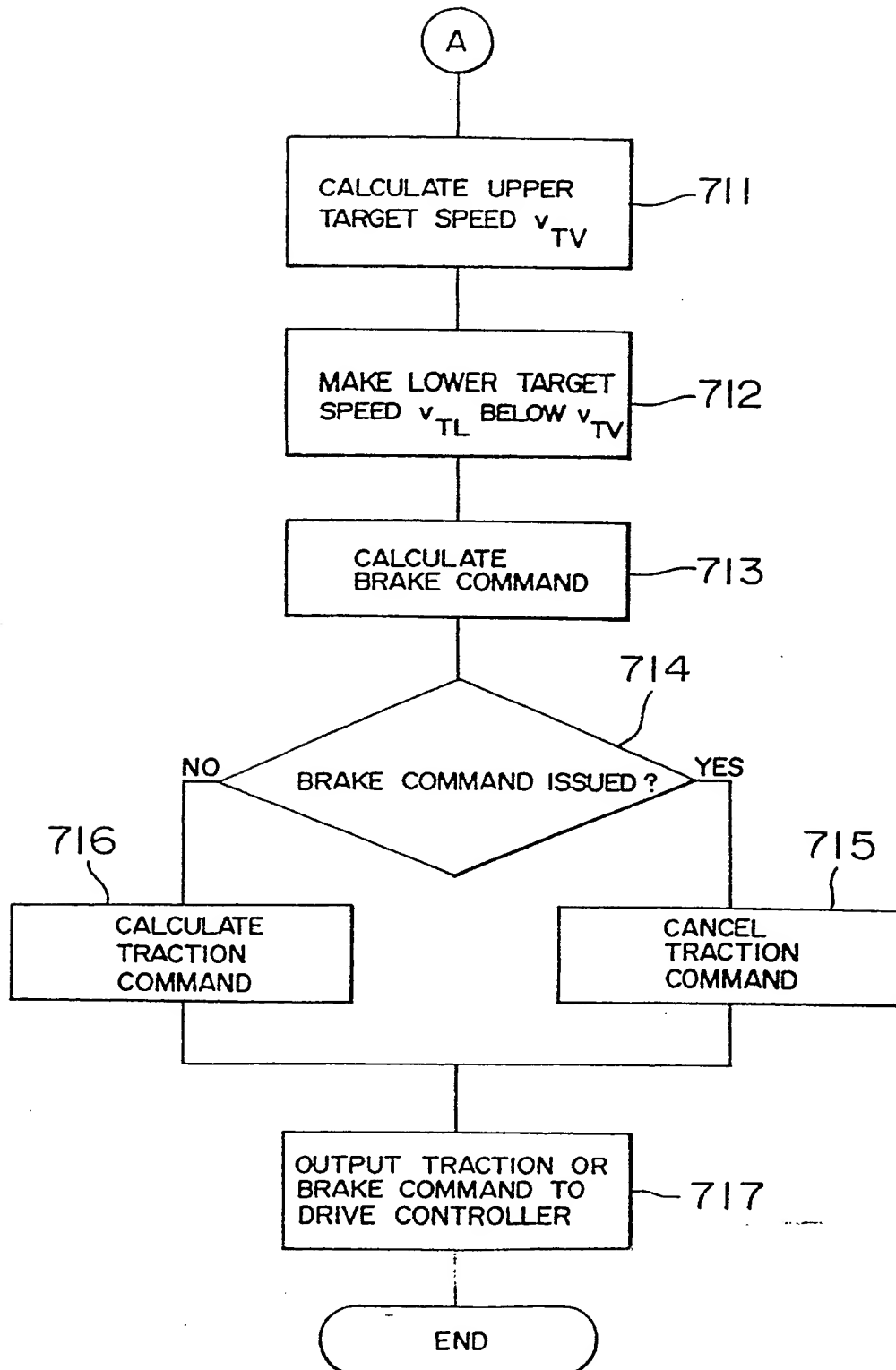
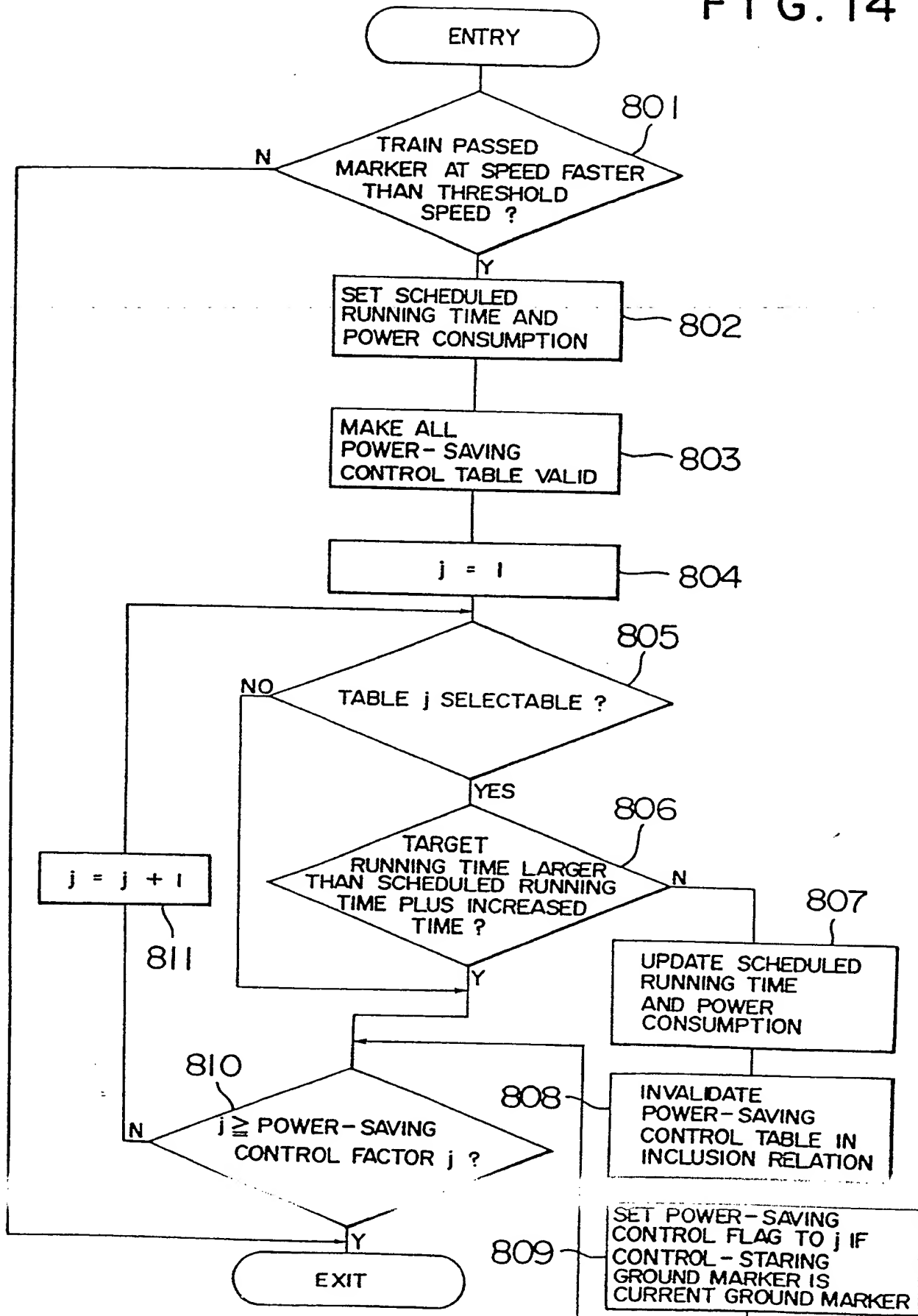


FIG. 14





DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Y	DE-A-3 026 652 (SIEMENS A.G.) *Page 8, line 17 - page 11, line 36; page 14, line 24 - page 16, line 34; figures 1,2,6*	1-5	B 60 L 15/20 B 61 L 3/00
Y	--- US-A-3 604 905 (SECHERON) *Column 1, lines 13-59; figures 1,3*	1	
Y	--- SCIENCE PROGRES LA NATURE, vol. 97, no. 3045, January 1969, pages 23-26, Paris (FR); P.DEVAUX: "Conduite électronique des trains et télécommande "radio-caténaire" ". *page 24, left-hand column, line 29 - page 25, right-hand column, line 13; figures 2,3*	1,2	
A	--- US-A-4 181 943 (L.I.MERCER) *Column 2, line 56 - column 3, line 12; figures 1,2* -----	1-5	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			B 60 L 15/00 B 61 L 3/00
Place of search THE HAGUE		Date of completion of the search 30-03-1984	Examiner WEIHS J.A.
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			